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Mediators of compassionate goal intervention effects on human neuroendocrine responses to the Trier Social Stress Test

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Abstract

Objectives: The hypothalamic-pituitary-adrenal (HPA) axis is thought to mediate the effects of stress on illness. Research has identified a limited number of psychological variables that modulate human HPA responses to stressors (e.g. perceived control and social support). Prosocial goals can reduce subjective stress, but have not been carefully examined in experimental settings where pathways of impact on biological stress markers may be traced. Recent work demonstrated that coaching individuals to strive to help others reduced HPA responses to the Trier Social Stress Test (TSST) relative to other cognitive interventions. However, identification of mediational pathways, which were not examined in the original study, is necessary to determine whether the HPA buffering effects were due to helping motivations (compassionate goals; CGs) rather than via previously identified variables such as control or support.

Methods: In this new analysis, we combined the original cortisol data with novel observer ratings of interpersonal behavior and psychological variables during the stress task, and conducted new, theory-driven analyses to determine psychological mediators for the intervention's effect on cortisol responses ($N=54$; 21 females, 33 males; 486 cortisol samples).

Results: Control, support, and task ego-threat failed to account for the effects of the intervention. As hypothesized, self and observer-rated CGs, as well as observer-rated perceptions of participants' interpersonal behavior as morally desirable (but not as dominant or affiliative) were significant mediators of neuroendocrine responses.

Conclusions: The findings suggest that stress-reduction interventions based on prosocial behavior should target particular motivational and interpersonal features.

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Disclosure statement

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Keywords

Trier Social Stress Test; compassionate goals; social cognition; cortisol; stress; HPA axis

When acutely activated, the hypothalamic-pituitary-adrenal (HPA) axis and its end-product cortisol facilitate adaptation to challenges (Tsigos & Chrousos, 2002), but chronic activation poses health risks (Lupien, McEwen, Gunnar, & Heim, 2009). Social cognitive processes that mediate or buffer HPA activation may shape its impact on health outcomes. Enhanced understanding of these processes may clarify stress-health linkages and inform stress-reduction interventions.

Laboratory studies have identified general psychological factors that stimulate HPA activation in humans, including low perceived control and social evaluative threat (Dickerson & Kemeny, 2004), whereas social support can reduce stress responses (Cosley, McCoy, Saslow, & Epel, 2010). Manipulation of perceived control and coping can buffer HPA responses to direct activation (Abelson, Khan, Liberzon, Erickson, & Young, 2008). However, in a psychosocial activation paradigm (Trier Social Stress Test [TSST], Kirschbaum, Pirke, & Hellhammer, 1993), interventions targeting these factors failed to reduce cortisol release, whereas instructing participants to shift from self-promotion to helping others (compassionate goals [CGs] intervention) successfully buffered HPA responses (Abelson et al., 2014). This study supported theorized stress-buffering properties of helping (Konrath & Brown, 2012), but was the first to document actual HPA buffering effects in a laboratory experiment, suggesting intriguing potential implications for stress coping interventions.

However, the study demonstrating HPA buffering by the CGs intervention did not examine actual mediators of the effect. There are multiple potential pathways. The intervention might impact known HPA moderators like perceived control or social support. It might *decrease* the perceived social evaluation threat of the TSST and the extent to which individuals strive to promote/defend the self (i.e. self-image goals, Crocker & Canevello, 2008). Alternatively, the intervention might operate via *increasing* CGs - striving to help others (Crocker & Canevello, 2008) - and behaviors related to basic dimensions of social cognition (Goodwin, Piazza, & Rozin, 2014; Haidt, 2003; Shweder, Much, Mahapatra, & Park, 1997): *dominance* (assertiveness versus submissiveness), *affiliation* (social closeness versus distance), and perceived *morality* (selfish/disgusting versus selfless/uplifting behavior; Algoe & Haidt, 2009; Zhong & Liljenquist, 2006). Higher dominance and affiliative interactions have predicted lower cortisol levels or reactivity (Gonzalez-Santoyo et al., 2015; Wiemers, Schoofs, & Wolf, 2013). Perceived morality (e.g. altruistic character) has not yet been examined as a cortisol release mediator, but robustly predicts social perceptions beyond dominance and affiliation (Goodwin et al., 2014). Additionally, CGs correlate with high affiliation (Crocker & Canevello, 2008) and perceived morality, but not dominance (Erickson et al., 2017), and predict reduced daily stress symptoms (Crocker, Canevello, Breines, & Flynn, 2010). If striving to help others accounts for the cortisol-buffering effects of the intervention, then future stress reduction efforts might fruitfully focus on the CGs construct and associated social cognitions related to affiliation and perceived morality.

We sought to identify psychosocial mediators of dampening effects of the CGs intervention on HPA responses, examining traditional predictors (control, support, and social evaluation), and variables specifically targeted by the intervention. The initial study examined between-group effects on cortisol and assessed psychosocial variables (e.g. control, support, evaluation) as *one-time*, single-item manipulation checks. The present analysis extends the original work by (1) incorporating reliable multi-item measures of mediator variables and repeated assessment during the TSST, (2) introducing new observer-rated variables (self-image goals, dominance, and perceived morality), and (3) utilizing a multilevel model to explicitly test which psychosocial variables predicted individuals' cortisol response curves and mediated intervention effects. If the intervention influenced cortisol via control and support, or by making the TSST seem less evaluative/ego-threatening, it may merely operate via known HPA modulators or by blunting task threat. On the other hand, if the intervention impacted cortisol by increasing prosocial processes, it would provide further support for a novel pathway for influencing stress responses. In line with the latter possibility, we hypothesized that higher self-reported and observer-rated CGs and associated dimensions of affiliation and perceived morality (but not dominance) would mediate intervention effects.

Methods

Participants

Fifty-four healthy adults (21 females, 33 males) participated in a study (see Abelson et al., 2014) testing brief cognitive interventions on HPA axis response to the TSST. They were recruited via community advertising, telephone screened by a trained research assistant, and evaluated in person (Structured Clinical Interview for DSM-IV) if they met screening criteria. Qualifying participants were 18–45 years old ($M=23.41$, $SD=6.06$) and physically and mentally healthy, without substance abuse. Females were premenopausal, not pregnant or lactating, not using birth control pills, and studied during luteal phase. All participants signed consent forms and received \$100. An Institutional Review Board approved the study.

Procedure

IV protocol and timing of tasks—The study, described to participants as a study of how public speaking affects stress hormones, was conducted at an academic medical research center after a screening visit. Intravenous access was established by 1:30 p.m. (18–20 gauge angiocatheter in an antecubital vein, kept open with a saline drip). Next, participants received a general introduction to the afternoon, learning that they would have an hour to get used to the IV, and then would participate in a speaking task (talking to a small group of people and video camera about qualifications for a job) and a thinking task, and that they would receive details immediately prior to the speaking task. The two cognitive intervention groups (see below) also received brief coaching (five minutes) on ways to cope with anxiety during public speaking, but were not told about task specifics and therefore were limited in their ability to prepare in advance.

Next, participants rested for one hour to accommodate to the research setting and IV. All participants were encouraged to engage in low-activation tasks (e.g. reading). Participants given the CGs intervention (see below) received a prompt to use some of their “reading”

time to list and reflect on their own prosocial values and career goals (all participants were aware that they would speak about job qualifications, but no details were provided until later). Blood samples were drawn at 2:10 p.m. (20min prior to the TSST) and 2:25 p.m. (immediately prior to TSST, “time 0”). The latter was used as a pre-speech “baseline” (not an absolute baseline because instructions had already been given). Participants then moved to another room to receive detailed task instructions (see below) and start the TSST. Additional blood samples were obtained after the speech task (10 min after start), after the math task (15 min after start), and at 25, 35, 45, 60, and 75 minutes after stress task initiation (back in the accommodation room), for a total of 486 samples.

TSST challenge—At the end of the accommodation phase, all participants were given detailed task instructions and reminders (see below), then three minutes to prepare. All participants received a personalized job description and gave a mock job presentation to two “evaluators” about why they were an ideal candidate for a job tailored to their particular interests. They spoke for five minutes, then were asked to serially subtract 13 s from 1022 as quickly as possible, while being videotaped and with live evaluators providing scrutiny without feedback. We followed standard TSST procedures (Kirschbaum et al., 1993) except that participants were randomly assigned to one of four experimental variations in instructions given.

The *standard instructions* (SI, $n=15$) group received the standard introduction described above, but to serve as a comparison for the “perceived control” condition, were also told that being observed while speaking can be stressful, and they could draw a curtain to shield themselves from observation if an indicator light was illuminated (the light was always off in this condition). Before starting, they were reminded about and shown the curtain.

Another group received the *standard introduction plus a manipulation of perceived control over threat* by being allowed to shield themselves from observation (SI Control; $n=16$). This was identical to the SI group except that the indicator light was lit for people in this group. These participants received a reminder just prior to the speech task itself, explaining that handing a yellow card marked “close” to the nurse present would provide a socially acceptable way for them to close the curtain and thereby limit being directly observed.

The *cognitive intervention to enhance familiarity and coping* (CI-Coping; $n=12$) group received coaching and instructions to cope with their anxious responses to the TSST by viewing them as non-threatening. specifically, expected physical and cognitive responses to public speaking tasks were reviewed and normalized, and participants’ own personal experiences of similar past sensations were elicited. Prior to the speech task, participants were reminded to interpret any anxious reactions to the task as familiar, expected, manageable, and harmless.

Lastly, a *cognitive intervention to shift mental focus from self-promotion to helping others* (CI-CG; $n=11$) was included. The CI-CG coaching and instructions emphasized how speaking about a desired job might elicit tendencies toward self-promotion and hiding one’s weaknesses (a competitive mindset), but recommended an alternative focus on thinking about how one might utilize new job opportunities to make a difference for others,

connecting to values beyond narrow self-interest (a compassionate mindset). Participants were invited to reflect on these motivations in their own personal experience. Before the TSST, they were reminded that they were helping the experimenters by investing full effort in both tasks. The interventions and their main effects are described in detail elsewhere (Abelson et al., 2014). Only the CI-CG intervention reduced HPA responses, so we examined effects of that intervention versus other conditions combined. Here, we sought to better understand what psychological or social cognitive factors mediated the stress-reducing effects of the CG intervention.

Measures

Self-report visual analog scales

Whereas the original study examined self-report variables only as single-item, one-time manipulation checks, here we included multi-item constructs for most variables, assessing most of these subjective states before, during, and after the TSST using visual analog scales (VASs) that quantified emotions/cognitions on 100-mm visual analog lines (*not at all to most ever*). Specifically, for this secondary analysis, we created multi-item measures of perceived control, social support, and compassionate and self-image goals as potential mediators of cortisol responses. Control items asked whether participants felt in control of what was happening to them, in control of their own responses, and had the situation under control, as well as (reverse-scored) sense of loss of control of physical sensations or of thoughts/feelings ($\alpha=.80$). Support items reflected the degree to which participants felt supported by the research staff, that research staff were helpful in getting through challenges posed by the study procedures, and that research personnel seemed intimidating or threatening (reverse-scored; $\alpha=.69$). Perceived negative evaluation, the only single-item self-report variable in this analysis, was assessed by asking “To what degree have you felt worried about being negatively evaluated?” Five CGs items, modified from Crocker and Canevello (2008), assessed wanting or trying, during the job speech, to pursue both approach (e.g. “to use the job to make a difference in the lives of others”) and avoidance goals (e.g. “avoid selfish or self-centered reasons for having the job”) related to helping others (all items averaged; $\alpha=.79$). Five items assessed self-image goals (e.g. “demonstrate my intelligence to others at the job”, “avoid coming across as incompetent or unintelligent”; $\alpha=.82$).

Participants completed the measures of perceived control, support, and negative evaluation at four time points: five minutes prior to the speech, at the end of the stress task, and 20 and 45 minutes post task. At the end of the stress task, participants reported the extent to which they felt they pursued compassionate and self-image goals during the task.

Observer-rated variables

Two trained observers, blind to hypotheses and condition, rated speech task video recordings, focusing on whether participants seemed to be motivated by compassionate and self-image goals, as well as levels of dominance, affiliation, and perceived morality of their verbal and nonverbal behavior. Compassionate goals were assessed with seven items (modified from Crocker & Canevello, 2008) reflecting participants’ apparent striving to use

the job in the service of helping others ($\alpha=.74$; intraclass correlation [ICC]=.64 in a subsample of 20 participants, suggesting inter-rater reliability). Self-image goals were rated via eight items reflecting striving to prove competence and avoid showing weaknesses ($\alpha=.88$; ICC=.50). Dominant behavior was assessed as the mean of *assertive*, *powerful*, and *forceful* ratings ($\alpha=.92$; ICC=.65), and affiliative behavior as the mean of *social*, *outgoing*, and *sociabler* ratings ($\alpha=.90$; ICC=.73). Perceived morality of intentions/behavior was assessed as the mean of *selfless*, *virtuous*, and *upstanding* ratings ($\alpha=.88$; ICC=.64). Observers rated all items on a 1 (*not at all*) to 5 (*extremely*) scale. Scores were standardized then averaged for participants as rated by both observers. Previous research documented the items' reliability, validity, and factor structure (Erickson et al., 2017).

Plasma cortisol assay

Cortisol was assayed via Coat-a-Count cortisol kits (Siemens, Washington, DC), a well-validated radioimmunoassay (RIA) with an analytical sensitivity of 0.2mcg/dl, as well as inter-assay and intra-assay variabilities of less than 5%.

Analysis plan

Few (1.4%) data were missing, requiring no imputation. Results were similar when controlling for sex, so we report models without sex. Our analysis plan included determining which of the potential mediating variables predicted participants' unique cortisol response curves (after first verifying average patterns of cortisol change in unconditional models). Then, we tested which potential mediator variables were impacted by the CGs intervention (versus all other participants). Lastly, we tested indirect effects (mediation) of the CI-CG intervention on cortisol response curves. We note that our predictor (intervention condition) temporally preceded other measurements. The potential mediators varied in timing; control, evaluation, and support variables were assessed before, at the end of, and after (20 and 45 minutes later) the stress task, whereas self-reported compassionate and self-image goals were assessed at the end of the task, and observer-rated mediators (goals, and dominance, affiliation, and morality) were assessed during the speech itself. Cortisol samples occurred repeatedly from immediately prior to the task to 75 minutes afterward. Given the natural lag of cortisol (e.g. peaking 10–30 minutes after a stressor begins; Foley & Kirschbaum, 2010), the one-time mediators (i.e. compassionate and self-image goals, all observer ratings) were assessed prior to when cortisol would peak, suggesting temporal precedence. However, we opted to use all available time points for mediators with repeated measures to avoid throwing away information, and because of our aim to predict individuals' cortisol growth curves rather than cortisol levels at specific time points.

Given that our predictor variable (condition) only exists as a “level 2” variable related to each person rather than one which varies within persons (level 1), it was only appropriate to test for between-person mediation (i.e. condition can influence cortisol curves via differences between participants in goals or other mediators; Zhang, Zyphur, & Preacher, 2009). Accordingly, for models with the mediator variable assessed repeatedly, we partialled out within-person variability to avoid confounding between- and within-person variability (see Zhang et al., 2009).

Hypotheses were tested within a multilevel modeling (MLM) growth curve analysis framework (Singer & Willett, 2003), which models between-person and within-person variability, handles unbalanced data, and does not assume independent errors. Cortisol scores (level 1) were nested within individuals (level 2). We computed restricted maximum likelihood estimates (REML) for parameters (SPSS MIXED command). We assumed an unstructured covariance structure, given better fit than alternatives (i.e. lower AIC indices). The time variable was coded as minutes from TSST initiation (time 0); intercepts reflected scores at that point. Predictors were grand-mean-centered so regression coefficients indicate individuals' deviations from the sample mean. We modeled random intercepts and random linear and quadratic time effects, assuming that cortisol trajectories varied across participants (random cubic time effects led to poor model convergence). Tests of effects of condition on outcome variables with a single assessment (e.g. behavior ratings) were conducted in a regression format, whereas all other tests were conducted via MLM.

Results

Predictors of cortisol growth curves

The unconditional models examining patterns of cortisol change (without predictors) showed significant linear ($b=.38$, $SE=.03$, $p<.001$), quadratic ($b=-.01$, $SE=.001$, $p<.001$), and cubic effects ($b=.00009$, $SE=.000007$, $p<.001$). Models including all three effects fit best (lowest AIC). Thus, the *average* participant showed a pattern of linear increase in cortisol, followed by deceleration of this increase as levels peaked (quadratic effect), and then decelerating decrease (cubic effect) returning to pre-stressor levels.

We then sought variables that might predict these time effects. Whereas the original study only examined overall group differences, our MLM analyses tested whether, and when during the stress task, psychosocial variables predicted deviations from the average cortisol linear, quadratic, and cubic change patterns noted above. We examined candidate mediator variables as predictors of intercepts (pre-speech levels) and flatter curves. A flatter response is characterized by reduced linear increase (negative predictor by time parameter), reduced deceleration of this increase (positive predictor by quadratic time² parameter), and reduced deceleration of the return to pre-stressor levels (negative predictor by cubic time³ parameter). With regard to general psychological variables previously linked to cortisol, higher perceived control predicted lower levels immediately after condition instructions (intercept), but not linear, quadratic, or cubic time effects (see Tables 1 and 2 for all parameter estimates). Perceived negative social evaluation predicted higher initial levels (intercepts) and flatter curves (reduced linear, quadratic, and cubic effects), suggesting that individuals who perceived social threat had higher cortisol early and thereby less extreme responses during the TSST. Perceived support during the task did not predict initial levels or changes.

With regard to novel interpersonal variables, self-reported self-image goals predicted less linear increase in cortisol, but no other effects; observer-rated self-image goals predicted no cortisol parameters. In contrast, the hypothesis that CGs would predict flatter cortisol responses was supported. Both *self-reported* and *observer-rated* CGs predicted flatter cortisol curves (linear, quadratic, and cubic effects, but not intercept). Observer-rated

affiliation (unexpectedly) and dominance (as expected) were not significant predictors of cortisol, whereas perceived morality did predict flatter cortisol curves, as hypothesized (Table 2). Overall, results confirm that self- and observer-ratings of participants' striving to help others predicted reduced cortisol responses. Perceptions of high task social threat and low control predicted higher initial cortisol levels, but a compassionate and morally desirable orientation predicted flatter cortisol curves in response to the social stressor.

Compassion group status predicting potential mediators

We then examined impact of the CI-CG intervention (coded as =1, all other groups =0) on candidate mediator variables. *Self-report variables* with repeated measures were analyzed via MLM. CI-CG group status did not predict perceived control ($b=-.41$, $SE=4.42$, $p=.926$), support ($b=-9.66$, $SE=5.76$, $p=.100$), negative social evaluation ($b=.16$, $SE=5.11$, $p=.975$), or self-image goals ($b=-11.19$, $SE=6.58$, $p=.096$). In contrast, group predicted higher self-reported CGs ($b=16.91$, $SE=7.79$, $p=.035$), as hypothesized. For *observer-rated variables*, linear regressions tested whether compassion group status predicted the candidate mediators. Group failed to predict observer-rated self-image goals ($b=-.32$, $SE=.31$, $p=.312$), but predicted higher observer-rated CGs ($b=1.29$, $SE=.27$, $p<.001$), affiliation ($b=.95$, $SE=.27$, $p=.001$), and perceived morality ($b=1.12$, $SE=.30$, $p=.001$), as expected. Group unexpectedly predicted higher dominance ($b=.73$, $SE=.32$, $p=.029$).

Tests of indirect effects

Finally, we conducted formal tests of mediation (indirect effects). We conducted Monte Carlo tests of indirect effects (Selig & Preacher, 2008), with 95% confidence intervals (CI) not including 0 indicating statistical significance (see Tables 1 and 2). For self-report variables, group status had significant indirect effects on cortisol via only CGs (linear, quadratic, and cubic effects). For observer-rated variables, group had significant indirect effects on cortisol via CGs and via perceived morality (linear, quadratic, and cubic effects for both). No other variables were significant mediators. These results reveal that the intervention led to flatter cortisol responses via individuals' greater conscious sense of striving to help others, and via observers' assessments that participants' behavior appeared compassionate and selfless.

Discussion

Abelson et al. (2014) showed that instructing individuals to focus on enhancing others' wellbeing reduced HPA responses during a social evaluative stressor, relative to both SI and alternative interventions designed to increase perceived control and coping. However, that study examined condition effects without examining how participants' perceptions predicted and mediated group effects on individual cortisol trajectories, leaving psychological mechanisms unknown. Here, we delved deeper, elucidating psychosocial mediators of this CG intervention effect in a multilevel analytic strategy that provided high resolution about cortisol curves. We assessed potential mediators with multi-item constructs and/or repeated measures over time, whereas the first study reported only one-time, single-item manipulation checks. We also incorporated new observer ratings of theory-relevant interpersonal processes (self-image goals, dominance, and perceived morality). We found that the intervention

reduced HPA responses via variables specifically targeted by the CGs intervention – self- and observer-rated CGs and perceived moral desirability (“morality”) but not via dominance or variables previously shown to modulate HPA activity (perceived control and affiliation/support). The results add a new dimension to research on psychological regulation of the HPA axis, with potential relevance to novel stress-reducing interventions.

Several variables previously linked to HPA modulation were unable to account for effects of the CGs intervention. Perceived control has a well-documented ability to reduce HPA responses to stressors (Dickerson & Kemeny, 2004), including direct pharmacological HPA activation (Abelson et al., 2008). Though perceived control did predict lower pre-speech cortisol, it did not affect response curves to the stressor, was not influenced by the CG intervention, and was not a significant mediator. Compassionate goals may increase perceived social support (Crocker & Canevello, 2008), which can reduce HPA activation during stressors (Cosley et al., 2010). However, perceived support from staff failed to predict HPA responses, was not influenced by the intervention, and was not a significant mediator. Lack of group effects on control and support is consistent with the single-item manipulation checks in the parent study, but this work provides stronger evidence by using more robust, multi-item measures. In addition, negative social evaluation and self-protective striving might constitute plausible mediators given that threat to the “social self” activates the HPA axis (Dickerson & Kemeny, 2004), and helping others has been theorized to buffer against stress by reducing self-focus (Konrath & Brown, 2012). However, although social evaluation did predict higher cortisol after TSST instructions and less subsequent change, it was not lower in the compassion condition, and did not significantly mediate effects on cortisol. Self-reported self-image goals unexpectedly predicted lower cortisol increase, which may reflect participants sense of successful “self-protection,” but observer reported self-image goals did not predict cortisol, and the compassion group was not significantly lower on either measure. These findings suggest that compassion intervention participants did not perceive the TSST as less of an ego-threat, ruling out the interpretation that their instructions somehow distracted them or otherwise made the task feel safer.

In contrast, CG group status predicted higher self-reported and observer-rated CGs, which emphasize *giving* support, and both predicted flatter TSST cortisol curves. Both indirect effects were significant, supporting our hypothesis that intervention effects on cortisol were due to prosocial processes rather than other variables. These data expand the original report by showing that impact of the CI-CG on the targeted construct of CGs was in fact the path to flattened cortisol curves. This result is consistent with studies on psychological benefits of giving support, above and beyond *receiving* it (Brown, Nesse, Vinokur, & Smith, 2003; Crocker et al., 2010), and extends such findings to biological stress reduction in an established laboratory model of psychosocial stress. Whereas recent studies found that writing a supportive letter to a friend (relative to a control group) reduced systolic blood pressure but not cortisol responses to the TSST (Inagaki & Eisenberger, 2016), and compassion meditation did not alter cortisol responses to the TSST (Pace et al., 2009), our findings confirm that prosocial strivings can buffer HPA responses to the TSST.

With regard to social cognition, the CG intervention also increased independent observer ratings of affiliation and the perceived moral desirability of participants’ TSST behavior, as

hypothesized. This suggests that the intervention fostered behavior that was outgoing and prosocial in a way perceived by others as selfless. The increase in affiliative behavior is consistent with previous studies linking CGs to closeness with others (Crocker & Canevello, 2008). However, the intervention also unexpectedly increased participants' dominance; individuals pursuing CGs also appeared to be strong or dominant. It is intriguing that the TSST elicited power/dominance motives but not affiliation motives in one study (Wiemers, Schultheiss, & Wolf, 2015), but in our work here the compassion intervention was associated with even higher dominance relative to participants receiving standard TSST instructions. This may be because having high CGs correlates with extraverted behaviors (Crocker & Canevello, 2008), which include dominance; however, any such dominance associated with CGs is contextualized by high affiliation and externally perceived selfless behavior. Striving to help others may sometimes be motivated by desires for dominance, but the fact that our intervention shifted self- and observer-rated perceptions of compassionate motivation is consistent with a measureable shift in cognitive set toward genuine motivation to support others.

However, among the three dimensions of social cognition, only perceived morality predicted flatter cortisol curves during the stress task, was altered by the CG intervention, and statistically mediated its cortisol effects. Theorists have posited a neurobehavioral caregiving system that may down-regulate stress reactivity (Gilbert, 2009; Wang, 2005), perhaps via opiate and oxytocin systems which are involved in pair bonding (Depue & Morrone-Strupinsky, 2005; Feldman, 2012). Evidence that rats will forgo rewards to help distressed conspecifics (Ben-Ami Bartal, Decety, & Mason, 2011) and neuroimaging studies of charitable giving (Hare, Camerer, Knoepfle, & Rangel, 2010; Moll et al., 2006) suggest a possible biological basis for such a system. Our observers' higher perceived morality ratings for the CG group may relate to this theorized caregiving system in that the self-sacrifice required of caregivers to nurture offspring may facilitate prosocial behaviors that others appraise as selfless. Although correlated with affiliation, perceived morality ratings have unique associations with CGs, prosocial traits, spirituality, and liking, beyond affiliation, suggesting that prosocial behavior and its effects are not reducible to mere seeking of proximity to others (Erickson et al., 2017; Goodwin et al., 2014; Rozin, Lowery, Imada, & Haidt, 1999). Perceived morality was our most robust social cognitive mediator of cortisol responses. Further work is needed to explore the potentially intersecting or independent roles of affiliation, morality, and theorized caregiving systems in the brain in shaping stress responding.

Implications

These data suggest that enhancing prosocial goals might provide a unique way to modulate HPA axis responses to social stress, consistent with interventions such as compassion meditation or loving-kindness meditation (Jazaieri et al., 2013; Pace et al., 2009). However, our intervention required only minutes of instruction, rather than the longer-term trainings of meditation studies, and emphasized specific prosocial goals in a particular context rather than general positive thoughts or feelings toward others. Despite brevity, it shaped subjective experiences and objectively observable behavior in a prosocial way, and reduced endocrine stress responses to a potent social stressor. These findings support further development and

examination of brief, transportable CG interventions and efforts to test them outside of the laboratory in the context of real-world stressors as well as in ill (e.g. depressed) samples. Attempts to transport the CG intervention into real-world contexts should attend to the perceived moral valence or desirability of behavior, helping individuals respond to others in a way that is not merely sociable but is also perceived as unselfish. Explicitly targeting these understudied variables may provide novel directions for stress intervention research.

Limitations

We note several limitations. The pattern of results remained present when we controlled for sex, but the analyses were not powered to provide a strong test of sex effects. The sample was not large, due to intensive blood sampling procedures; however, our multilevel analytical strategy increased power by taking advantage of repeated assessments (486 observations). Growth curve modeling procedures required tests for linear, quadratic, and cubic effects, increasing tests but also providing high resolution about cortisol change patterns. Mediation effects on multiple cortisol curve parameters for both self- and observer-reported CGs suggest a robust effect. Also, because researchers have found it challenging to elicit CGs experimentally (Crocker & Canevello, 2012), we created a relatively “strong” CG intervention manipulation with multiple elements (instructions, values reflection, reminders, coaching). This provided a detectable impact on cortisol, but future studies should dismantle these elements to determine which ones are most salient. Future studies should also further examine whether a CG intervention may also reduce self-image goals and fear of negative evaluation. We did not directly assess participants’ perceptions of how the interviewers perceived them; it is possible that participants’ belief that they projected prosocial characteristics may have shaped cortisol responses, so future studies should assess this process. Prosocial behavior may be accompanied by an expectation of reciprocity; those who behave prosocially may expect to receive prosocial responses from others, and such expectations may be stress-reducing. Nonetheless, perceived staff support, which did not impact cortisol levels, may indirectly assess this process in that viewing staff as supportive implies a sense of being viewed favorably by them. Lastly, although we used the term *morality* as a shorthand for selflessness following recent trends in social cognition research (Goodwin et al., 2014), we note that perceived morality involves socially and culturally complex phenomena, warranting further construct clarification.

Conclusions

Despite limitations, this research provides novel evidence of *how* prosocial behavior may shape HPA responding. Our mediation analyses shed further light on the original finding that a CGs intervention buffered HPA responses to a well-established psychosocial stressor. They demonstrate that stress-buffering occurred via an interpersonal orientation toward selflessness, captured in self-reported and observer-rated orientation toward giving to others and observer-rated moral desirability, and not via previously documented mediators like control or support, nor via merely reducing ego-threat of the task. Use of observer ratings provided a deeper examination of interpersonal behavior than in previous TSST studies. The results attest to the idea that in the context of human social threats, striving to adopt a prosocial mindset of caring about others may have potential value for stress modulation,

suggesting a novel direction for both basic science on psychological modulation of the HPA axis and for future research on stress interventions.

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Table 1.

Self-report psychological predictors and potential mediators of cortisol responses to TSST.

Predictor	Effect	Cortisol			Indirect Effect 95% CI
		<i>b</i>	<i>SE</i>	<i>p</i>	
Perceived control	Predictor	−0.03	0.01	.036	−.55, .49
	Predictor × time	0.002	0.001	.076	−.14, .13
	Predictor × time ²	−0.00007	0.00004	.070	−.002, .002
	Predictor × time ³	0.0000006	0.0000003	.069	−.00003, .00004
Perceived evaluation	Predictor	0.11	0.50	.035	−.54, .58
	Predictor × time	−0.01	0.01	.018	−.12, .11
	Predictor × time ²	0.0005	0.0002	.025	−.01, .01
	Predictor × time ³	−0.0000045	0.000002	.033	−.00003, .00003
Perceived support	Predictor	−0.04	0.03	.273	−.47, 1.06
	Predictor × time	−0.00007	0.004	.987	−.19, .04
	Predictor × time ²	0.0001	0.0002	.515	−.003, .006
	Predictor × time ³	−0.000002	0.000002	.363	−.00006, .00004
Self-image goals	Predictor	−0.002	0.028	.955	−.66, .89
	Predictor × time	−0.003	0.002	.047	−.01, .11
	Predictor × time ²	0.000058	0.00004	.148	−.002, .0003
	Predictor × time ³	−0.0000002	0.0000003	.384	−.00001, .000004
Compassionate goals	Predictor	0.01	0.02	.691	−.82, 1.09
	Predictor × time	−0.004	0.001	.001	−.18, −.01
	Predictor × time ²	0.0001	0.00003	.001	.0001, .004
	Predictor × time ³	−0.0000008	0.0000003	.006	−.00003, −.0000006

“Predictor” effects reflect effect of each predictor (e.g. control) on the intercept of cortisol (i.e. pre-speech, but post-induction levels). Indirect effects reflect significant effects of intervention condition on cortisol via each mediator. Significant effects are bolded.

Table 2.
Observer-rated psychological predictors and potential mediators of cortisol responses to TSST.

Predictor	Cortisol				
	Effect	b	SE	p	Indirect Effect 95% CI
Self-Image goals	Predictor	0.34	0.67	.614	-.89, .47
	Predictor × time	0.07	0.04	.092	-.001, .002
	Predictor × time ²	-0.002	0.001	.082	-.09, .02
	Predictor × time ³	0.00002	0.00001	.113	-.00002, .000006
Compassionate goals	Predictor	0.03	0.64	.961	-1.69, 1.94
	Predictor × time	-0.08	0.04	.043	-.20, -.02
	Predictor × time ²	0.002	0.001	.016	.0003, .005
	Predictor × time ³	-0.00002	0.000008	.033	-.000006, -.00005
Dominance	Predictor	0.42	0.70	.495	-.70, 1.38
	Predictor × time	-0.06	0.04	.119	-.01, .13
	Predictor × time ²	0.001	0.001	.401	-.001, .003
	Predictor × time ³	-0.000002	0.000008	.802	-.00001, .00001
Affiliation	Predictor	-0.05	0.70	.947	-1.51, 1.37
	Predictor × time	-0.05	0.04	.247	-.14, .03
	Predictor × time ²	0.001	0.001	.277	-.001, .003
	Predictor × time ³	-0.000006	0.000009	.468	-.00002, .000002
Perceived morality	Predictor	0.02	0.61	.979	-1.50, 1.49
	Predictor × time	-0.10	0.04	.006	-.22, -.03
	Predictor × time ²	0.002	0.001	.005	.001, .007
	Predictor × time ³	-0.00002	0.000008	.034	-.0003, -.0001

"Predictor" effects reflect effect of each predictor (e.g. control) on the intercept of cortisol (i.e. pre-speech, but post-induction levels). Indirect effects reflect significant effects of intervention condition on cortisol via each mediator. Significant effects are bolded.